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# DEVELOPMENT AND THE DEPLOYMENT OF COSAGE 2.0

Nathan Dietrich
David N. Smith
Doug Edwards

Center for Army Analysis
6001 Goethals Road
Fort Belvoir, Virginia 22060-5230, USA

## ABSTRACT

The COmbat SAmple GEnerator (COSAGE) model is a stochastic, symmetric, two-sided combat simulation model implemented in SIMSCRIPT II.5. This model is primary used as a calibration for Attrition Calibration (ATCAL) base theater-level models including the Joint Integrated Contingency Model (JICM), Synthetic Theater Operations Research Model (STORM) (AF, follow-on to Thunder), and Integrated Theater Engagement Model (ITEM) (Navy). In 2009 it was determined that CAA would re-write the model in C++ in order to improve the modularity, ability to enhance the methodology and model maintenance. This paper focuses on the entire development process of the new model from the decision to re-write the model to the testing and evaluation prior to model deployment.

## 1 INTRODUCTION

The U. S. Army's Center for Army Analysis (CAA) has the responsibility for modeling ground combat attrition and providing combat sample input for Department of Defense (DoD) theater-level campaign models (Synthetic Theater Operations Research Model (STORM) and Joint Integrated Contingency Model (JICM)). CAA accomplishes this by using the Combat Sample Generator (COSAGE) model. COSAGE's primary purpose is to produce combat samples that are used to adjudicate ground combat attrition in theater-level campaign models.

The Center for Army Analysis developed the COSAGE model in the early 1980s. CAA originally wrote the model code in the SIMSCRIPT II.5 programming language. In 2009, CAA decided to re-write the model in C++ language in order to improve the modularity, the ability to employ code programmers, the ability to enhance the methodology and to improve the model maintenance. This paper focuses on the entire developmental process of the new model from the decision to re-write the model to the testing and evaluation prior to model deployment.

The COSAGE model is a two-sided, symmetrical, medium-resolution, stochastic simulation model that models tactical-level combat between two forces. The function of this model is to take static (laboratory) probability of kill (PK) values and convert them, under simulated joint combined arms battle conditions, to operational PK values that are then used as input in theater-level campaign modeling. The COSAGE model provides a sample set of system on system effectiveness tables (the combat sample) based on doctrine, weapon performance characteristics, and operational combat situations.

COSAGE resolution is at the platoon level for the opposing forces. COSAGE models soldier-level individual small arms up to the largest heavy armor and indirect fire systems. In addition, COSAGE models representation of fixed and rotary wing air assets, unmanned aerial vehicles, and air defense systems. COSAGE inputs include Army Material Systems Analysis Activity (AMSAA) system performance data, scenario data which includes force composition/size and weapons mix (order of battle), tactics, techniques, and procedures (TTPs), doctrine, terrain, and key battle engagements represented in

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different mission postures (i.e., blue attack red prepared defense (BARP), blue hasty defense red attack (BHRA), etc.).

## 2 THE COSAGE ROAD AHEAD

In the summer of 2009 while identifying the COSAGE road ahead, CAA was faced with the decision to either continue development and improvement of the COSAGE model for the production of combat samples or consider the replacement of COSAGE with another combat model that could provide the same input for theater-level campaign models. The goal of the decision was to ensure that CAA made the best use of available resources, both people's time and any funds available. CAA wanted the payoff to be a significantly improved representation of ground combat operations within the theater-level campaign models and possibly expanded analysis available for Headquarters, Department of the Army (HQDA).
The COSGAE Road Ahead plan was to analyze and develop a plan that could be implemented by the fall of 2009. The objectives of the Road Ahead plan were:

1. To determine whether to conduct a rewrite of code effort or replace with another model.
2. Become the system on system / doctrine center of excellence at CAA (e.g., TTPs for brigade and below with division enablers).
3. Continue periodic COSAGE Integrated Product Team (IPT) meetings to ensure buy in from the Army community.
4. Organize better to support the challenges.

Since COSAGE's primary purpose is to produce combat samples that are used to adjudicate ground combat attrition in theater-level campaign models, systems must interact with other systems in the COSAGE model for those systems to interact within the theater-level campaign model. In a single COSAGE combat sample, there is the possibility of thousands of system on system interactions. In addition to these interactions, COSAGE models the doctrine and TTPs of the opposing forces. Throughout the history of COSAGE, there has been a constant struggle between ensuring that the doctrine of the opposing forces is modeled accurately while ensuring the maximum number of possible system on system interactions occur within the combat sample. Regardless of whether to rewrite the code of the COSAGE model or replace it with another model, the model chosen must be able to model both doctrine and the interactions of the opposing systems.

Like all combat models, COSAGE had some modeling gaps. The COSAGE model gaps included:

1. Post processing capabilities.
2. Ability to model new systems like beyond line of sight (BLOS) systems, smart mines, etc.
3. Tactical maneuver to a position of advantage.
4. Command, control, communications, computers, intelligence, surveillance, and reconnaissance (C4ISR) versus ground truth.
5. Direct fire and indirect fire improvements.
6. Enhanced play back of COSAGE battle to help analyze the combat.
7. Fixed and rotary wing improvements.

## 3 IDENTIFYING A COSAGE REPLACEMENT

When considering whether to rewrite the code of the COSAGE model or to replace it with another model, the level of the ability of other combat models to address the COSAGE modeling gaps where taken into consideration. If the other combat models that CAA looked at also had some of these modeling gaps, the difficult or ease of these combat models to incorporate these capabilities was considered.

Even though there were COSAGE modeling gaps, throughout the history of the model and during this timeframe, CAA had continued to update and improve COSAGE. Some of these improvements included:

1. Improved small arms representation.
2. Integrated Matrix Evaluator (ME) methodology.
3. Corrected precision munitions employment.
4. Integrated battery computer system (BCS) aim point methodology.
5. Updated improved conventional munitions (ICM) damage function.
6. Automated COSAGE post-processing tools.

The level of the ability of other combat models to address the COSAGE modeling improvements was also taken into consideration.

CAA considered the following combat models as possible model replacements for COSAGE:

1. Advanced Warfighting Simulation (AWARS).
2. Combat XXI.
3. OneSAF.

CAA used the criteria found in Table 1, in evaluating whether to rewrite the code of the COSAGE model or to replace it with another model:

Table 1:COSAGE Model Replacement Criteria

| | Rewrite of Code Effort | Replace with another Model (AWARS, Combat XXI, or OneSAF) |
|---|---|---|
| Control of model / code | ✓ | |
| Time to produce combat samples for a new scenario from scratch | ✓ | |
| Rewrite of input / output processes to support model | ✓ | |
| Doctrine / TTPs | ✓ | ✓✓ |
| Interactions | ✓✓ | |
| Time to train analysts | ✓ | |
| Cost of acquiring upgraded model | | ✓ |
| Addresses Key Modeling Gaps | ✓ | ✓ |

Based upon the criteria, CAA decided to fund a rewrite of the SIMSCRIPT II.5 model to a more modern programming language (C++). The CAA COSAGE Production Branch worked with the approved contractor to capture the COSAGE capabilities, which fell under two broad categories:

1. Current COSAGE capabilities.
2. Desired future COSAGE capabilities to include on-going model enhancements.

CAA wanted to ensure that not only was COSAGE re-written in C++ code that was able to produce combat samples as were currently being produced, but that the new code would enhance the ability to add new capabilities to the model.

## 4 DEVELOPMENT OF THE COSAGE 2.0 MODEL

Working with the contractor, CAA determined that the re-write of the model code would be conducted in two phases:

1. Phase 1: re-write of the code into C++ based on the development roadmap as identified and prioritized in a manner as to insure the desired future capabilities could be readily incorporated into the COSAGE simulation system. This task produced a functional prototype model with limited functionality.
2. Phase 2: implement the approved re-write C++ development roadmap as identified concentrating on the input parsers, core functionalities, and output processors. The re-write was to insure that desired future capabilities could be readily incorporated into the COSAGE simulation system. This task produced a fully developed model that produced combat samples that could be used as input into theater-level campaign models.

During the 18 month conversion process, CAA conducted weekly meetings with the contractor to assist the C++ programmers in understanding the purposes of the model and to address any issues, "bugs", and errors identified during the conversion project. Numerous software "bugs" were identified in the old SIMSCRIPT II.5 programming code and corrected during the conversion project. Also, the contractor identified and corrected a smaller number of logic errors.

CAA understood that the new C++ COSAGE model would not produce identical results as the SIMSCRIPT II.5 model, but that any differences would be able to be explained satisfactorily.

CAA received the updated COSAGE model (C++) on 30 March 2011 and began to conduct testing and evaluation of the updated model code. The updated COSAGE model (C++) utilizes the Common Analytic Simulation Architecture (CASA) which is a library of reusable C++ tools designed to support stochastic, discreet-event, simulation models.

The contractor developed CASA for the United States Air Force (USAF) and is used in the theater-level campaign STORM model. The USAF provided the source code for CASA to CAA allowing the code to be modified as needed. With the USAF providing this code, CAA was able to save much needed funds and time in the re-write of COSAGE. By using CASA as the framework for the re-write, CAA got the benefit of the following:

1. Allowed the development to focus on the core model instead of re-invention of simulation infrastructure (clock, event queue, event scheduling, data-handling, reports, maps, graphing, etc.).
2. Code is United States Government owned.
3. The code is already developed, debugged and currently in use.
4. The contractor wrote CASA; hence no additional time learning a new C++ library.

5. CAA received the CASA code for free.

## 5 COSAGE 2.0 TESTING METHODOLOGY

Prior to receiving the updated COSAGE model (C++), CAA developed a test and evaluation plan for the updated COSAGE model to identify any errors, make corrections where possible in order to make a recommendation to the CAA leadership on the ability of this model to adequately represent ground combat and produce output suitable for use in DoD theater-level campaign models. The objectives of the test and evaluation plan included the following:

1. The update of the format of the input files for COSAGE.
2. Install the updated model in UNIX.
3. Train COSAGE analysts.
4. Analyze the model output (combat samples) and compare the output to output from the SIMSCRIPT II.5 model.
5. Ensure that the combat samples are verified for use in a theater-level campaign model.

For the comparison of the updated COSAGE model output to the SIMSCRIPT II.5 model output, CAA developed the following essential elements of analysis (EEAs) and measures of effectiveness (MOEs):

1. EEA 1: Is there a statistical difference between the direct fire system-level performances?
   a. MOE 1.1 – Direct fire shots.
   b. MOE 1.2 – Direct fire kills.
   c. MOE 1.3 – Hits on dead targets.
   d. MOE 1.4 – Average ranges of direct fire weapons.
   e. MOE 1.5 – Kills per shot.
   f. MOE 1.6 – Shots per system per day.
2. EEA 2: Is there a statistical difference between the indirect fire system-level performances?
   a. MOE 2.1 – Indirect fire shots.
   b. MOE 2.2 – Indirect fire kills.
   c. MOE 2.3 – Indirect fire assessed shots (K records).
   d. MOE 2.4 – Average ranges of indirect fire systems.
   e. MOE 2.5 – Shots per system per day.
3. EEA 3: Is there a statistical difference between the exchange ratios?
   a. MOE 3.1 – Fractional Exchange Ratio (FER).
   b. MOE 3.2 – Loss Exchange Ratio (LER).
   c. MOE 3.3 – Share of kills by type of shooter.
4. EEA 4: Is there a statistical difference between the numbers of battle per mission postures?
   a. MOE 4.1 – Number of battles per mission postures.
5. EEA 5: How do the results represent interactions?
   a. MOE 5.1 – Percent of possible shooter-target interactions.
   b. MOE 5.2 – Number of systems that did not shoot at any target.
   c. MOE 5.3 – Number of systems that shot but did not kill any target.
   d. MOE 5.4 – Number of systems that were not killed.
6. EEA 6: Do the input files contain the same information?

   a. MOE 6.1 – Unit size.
   b. MOE 6.2 – Unit composition.
   c. MOE 6.3 – Unit location.
   d. MOE 6.4 – PKs, illumination, munition priority (attack guidance matrix for indirect fires), high explosive (HE) lethal areas, etc.
7. EEA 7: Performance issues: Does the updated COSAGE model operate equal to or better than the previous COSAGE model?
   a. MOE 7.1 – The speed to run six mission postures with 30 repetitions is similar to the previous speed.
   b. MOE 7.2 – The system memory requirement is similar to that of the previous COSAGE model.
   c. MOE 7.3 – The system can support the same number of multiple users simultaneously.
8. EEA 8: Do the updated COSAGE model results realistically represent combat?
   a. MOE 8.1 – Engagement ranges, shots/kills, hits on dead targets, etc. are realistic. Applies to infantry, armor, aviation, field artillery and air defense systems.

For the test and evaluation plan, CAA developed the following methodology:

1. Preparation of the updated COSAGE model:
   a. The update of the format of the input files for COSAGE.
   b. Install the updated model in UNIX.
   c. Train COSAGE analysts.
2. Produce COSAGE model output (combat samples) from both versions of the model.
3. Analyze and compare the output from both versions.
4. Provide updated COSAGE model output to a theater-level campaign model for evaluation.
5. Provide the theater-level campaign model output to CAA's Logistics Division for their analysis and evaluation.
6. COSAGE Production Branch provides a briefing to the CAA's leadership on the analysis.

During the production and analysis of COSAGE model output, the COSAGE Production Branch planned to test multiple different scenarios. These scenarios included:

1. Small direct fire only vignettes.
2. Small indirect fire only vignettes.
3. Small direct and indirect fire vignettes.
4. Full-up scenarios that are routinely produced for theater-level campaign models.

Starting with smaller vignettes enabled the COSAGE Production Branch to be able to analyze the results easier, determine updated code "bugs" or errors, and determine the way ahead to fix the "bugs" and errors.

## 6 COSAGE 2.0 NOW

After CAA received the updated COSAGE model (C++) on 30 March 2011, CAA began to conduct the testing and evaluation of the updated model code immediately. As of June 2011, the Center for Army Analysis was still conducting the testing and the evaluation of the updated COSAGE model. The COSAGE Production Branch had identified several software "bugs", corrected some of the "bugs", and

was in the process of fixing the remaining "bugs" prior to the COSAGE modeling of the full-up combat scenarios required for theater-level campaign modeling.

Throughout the process of determining to re-write the model through the testing and evaluation prior to model deployment, CAA will improve their ability to improve the modularity, improve the ability to employ code programmers, improve the ability to enhance the methodology and to improve the COSAGE model maintenance. Due to these updated COSAGE improvements, CAA will be better able to provide realistic representation of ground combat operations within the theater-level campaign models and expand analysis available for HQDA.

## AUTHOR BIOGRAPHIES

**NATHAN DIETRICH** enlisted in the US Army in 1989 as a MOS 11B. He received his commission as an Infantry Officer from OCS. After graduating Infantry Officer's Basic Course, Ranger School, Airborne School, and the Infantry Officer's Mortar Leader Course, he served as a Rifle Company Platoon Leader and a Rifle Company Executive Officer with 1/503rd Infantry Battalion (AASLT), 2nd Infantry Division, Korea from April 1991 to March 1993. Mr. Dietrich's next assignment was with the 1/509th Parachute Infantry Regiment (ABN), the OPFOR Battalion as the Joint Readiness Training Center, where he served as a Rifle Company Platoon Leader and a Rifle Company Executive Officer from May 1993 to October 1994. After completion of the Infantry Officer's Advanced Course in 1995, he served in the 25th Infantry Division as 3rd Brigade's Assistant S3 Plans Officer. Mr. Dietrich then commanded Headquarters and Headquarters Company, 1/506th Infantry Battalion (AASLT), 2nd Infantry Division, Korea from July 1998 to July 1999. After command, Mr Dietrich was selected to attend Advanced Civil Schooling. He attended the Naval Postgraduate School and earned his Master of Science Degree in Operations Research in June 1001. He was then assigned as an Operations Research Analyst in the Wargaming Directorate of the TRADOC Analysis Center White Sands Missile Range (TRAC-WSMR) from July 2001 to August 2004 where he worked with the Janus model providing analysis for the Future Combat System (FCS) and Task Force Modularity, the redesign of the current forces. While at TRAC-WSMR, Mr. Dietrich graduated for the Functional Area 49 Qualification Course at Fort Leavenworth, KS in July 2004. Mr. Dietrich arrived at CAA in September 2004 where he worked as an Operations Research Analyst in the Campaign Enablers Division. Mr. Dietrich retired from the Army in April 2009, and then when to work at CAA as an ORSA in the Campaign Enablers Division. Mr. Dietrich is married to Viyada and they have one daughter, Alicia (21). His email address is nathan.dietrich@us.army.mil.

**DAVID SMITH** is currently serving as an Operations Research Analyst (ORSA) in the Campaign Analysis (CA) division as a member of the COSAGE Production Team. This subdivision of CA has the responsibility of producing COSAGE combat samples for all campaign scenarios run in CAA's theater level model (JICM). Most recently, Mr. Smith has been responsible for identifying coding errors in the recently delivered COSAGE 2 model. Previous to this he was a member of the COSAGE production team and was responsible for the development, analysis and delivery of combat samples to the customers. In prior assignments Mr. Smith was a theater level modeler, who performed theater level analysis using the Concepts Evaluation Model (CEM). Mr. Smith holds a Master of Science degree in Operations Research from George Mason University and a Bachelors of Science in Computer Science from Rochester Institute of Technology. His email address is david.n.smith@us.army.mil

**DOUG EDWARDS** is currently serving as an Operations Research Analyst (ORSA) in the Campaign Analysis (CA) division as a member of the COSAGE Production Team. This subdivision of CA has the responsibility of producing COSAGE combat samples for all campaign scenarios run in CAA's theater level model (JICM). He most recently was responsible for the coordination of the COSAGE combat model re-write from SIMSCRIPT II.5 into C++. Previous to this he was responsible for the coordination of the development, analysis and delivery of combat samples to the customer as the team chief of the

COSAGE production team. Prior to coming to CAA, Mr. Edwards served as the Fort Sill Network Information Assurance Manager, Fort Sill, OK. Prior to joining the Federal Civil Service, Mr. Edwards taught in the Mathematics Department of Cameron University from Aug 1985 to June 1992. Mr. Edwards holds a Master of Science degree in Mathematics from Clemson University and a Bachelors of Science from Georgia College. His email address is miles.edwards@us.army.mil